CLAIMS

What is claimed is:

1. A method of performing frequency domain excision on a received signal including a desired wideband signal component, comprising:

applying a window function to each of overlapped blocks of samples of the received signal to generate windowed blocks of signal samples, the window function having a central maximum and tapering to zero at beginning and ending points;

performing a predetermined transform function on each of the windowed blocks of signal samples to generate corresponding blocks of frequency-domain coefficients;

for each block of frequency-domain coefficients:

(1) morphologically filtering the coefficients to generate a threshold function representing an estimate of the spectrum of the desired wideband signal component, the threshold function including a plurality of threshold values corresponding to the coefficients; and

(ii) applying a gain function to each coefficient to generate an excised block of coefficients, the gain function for each coefficient having a fixed-gain region for input values less than the corresponding threshold value from the threshold function, an excision region for input values greater than a predetermined multiple of the corresponding threshold value, and a soft limiting region between the fixed-gain region and the excision region;

performing the inverse of the transform function on the excised blocks of coefficients to generate excised blocks of signal samples; and

applying an overlap-eliminating central portion of the inverse of the window function to each excised block of signal samples.

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2. A method according to claim 1, wherein the blocks of signal samples overlap by an amount in the range of 25% to 75%.

3. A method according to claim 2, wherein the blocks of signal samples overlap by 50%.

4. A method according to claim 1, wherein the blocks of signal samples overlap by 50% and the central portion of the inverse window function is the central 50% of the inverse window function.

5. A method according to claim 1, wherein the morphological filtering of each block of frequency-domain coefficients comprises:

performing a grayscale closing of the coefficients by (i) calculating a first function having values corresponding to the coefficients, each value of the first function being equal to the value of the largest coefficient in a small neighborhood of the corresponding coefficient as defined by a first kernel, and (ii) calculating a second function having values corresponding to the values of the first function, each value of the second function being equal to the smallest value in a small neighborhood of the corresponding value of the first function as defined by the first kernel; and

performing a grayscale opening of the second function by (i) calculating a third function having values corresponding to the values of the second function, each value of the third function being equal to the smallest value in a large neighborhood of the corresponding value of the second function as defined by a second kernel, and (ii) calculating a fourth function having values corresponding to the values of the third function, each value of the fourth function being equal to the largest value in a large neighborhood of the corresponding value of the third function as defined by the second kernel.

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6. A method according to claim 5, wherein the first kernel has a size of less than one percent of the number of coefficients in each block and the second kernel is about ten times larger than the first kernel.

7. A method according to claim 6, wherein the size of the first kernel is about 5, and the size of the second kernel is about 50.

8. A method according to claim 1, wherein the predetermined multiple defining the excision region is about 2.

9. A method according to claim 1, wherein the gain in the soft limiting region falls off in proportion to the square of the normalized difference between the value of the coefficient and the threshold value.

10. A method according to claim 1, further comprising convolving the output of the gain function with a spreading function to reduce the time extent of the effect of the excision on the excised blocks of signal samples.

11. An excision system for performing frequency domain excision on a received signal including a desired wideband signal component, comprising:

a window component operative to apply a window function to each of overlapped blocks of samples of the received signal to generate windowed blocks of signal samples, the window function having a central maximum and tapering to zero at beginning and ending points;

a transform component operative to perform a predetermined transform function on each of the windowed blocks of signal samples to generate corresponding blocks of frequency-domain coefficients;

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an excision processing component operative for each block of frequency-domain coefficients to:

(1) morphologically filter the coefficients to generate a threshold function representing an estimate of the spectrum of the desired wideband signal component, the threshold function including a plurality of threshold values corresponding to the coefficients; and

(ii) apply a gain function to each coefficient to generate an excised block of coefficients, the gain function for each coefficient having a fixed-gain region for input values less than the corresponding threshold value from the threshold function, an excision region for input values greater than a predetermined multiple of the corresponding threshold value, and a soft limiting region between the fixed-gain region and the excision region;

an inverse transform component operative to perform the inverse of the transform function on the excised blocks of coefficients to generate excised blocks of signal samples; and

an inverse window component operative to apply an overlap-eliminating central portion of the inverse of the window function to each excised block of signal samples.

12. An excision system according to claim 11, wherein the blocks of signal samples overlap by an amount in the range of 25% to 75%.

13. An excision system according to claim 12, wherein the blocks of signal samples overlap by 50%.

14. An excision system according to claim 11, wherein the blocks of signal samples overlap by 50% and the central portion of the inverse window function is the central 50% of the inverse window function.

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15. An excision system according to claim 11, wherein the morphological filtering of each block of frequency-domain coefficients comprises:

performing a grayscale closing of the coefficients by (i) calculating a first function having values corresponding to the coefficients, each value of the first function being equal to the value of the largest coefficient in a small neighborhood of the corresponding coefficient as defined by a first kernel, and (ii) calculating a second function having values corresponding to the values of the first function, each value of the second function being equal to the smallest value in a small neighborhood of the corresponding value of the first function as defined by the first kernel; and

performing a grayscale opening of the second function by (i) calculating a third function having values corresponding to the values of the second function, each value of the third function being equal to the smallest value in a large neighborhood of the corresponding value of the second function as defined by a second kernel, and (ii) calculating a fourth function having values corresponding to the values of the third function, each value of the fourth function being equal to the largest value in a large neighborhood of the corresponding value of the third function as defined by the second kernel.

16. An excision system according to claim 15, wherein the first kernel has a size of less than one percent of the number of coefficients in each block and the second kernel is about ten times larger than the first kernel.

17. An excision system according to claim 16, wherein the size of the first kernel is about 5, and the size of the second kernel is about 50.

18. An excision system according to claim 11, wherein the

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predetermined multiple defining the excision region is about 2.

19. An excision system according to claim 11, wherein the gain in the soft limiting region falls off in proportion to the square of the normalized difference between the value of the coefficient and the threshold value.

20. An excision system according to claim 11, further comprising a convolving component operative to convolve the output of the gain function with a spreading function to reduce the effect of the excision on the excised blocks of signal samples.

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